



# From Bench to Backyard

*EPA Patents at Work Protecting  
Human Health and the Environment*







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Welcome to a sampling of environmental technologies in action! The U.S. EPA Federal Technology Transfer Act (FTTA) Program facilitates the transfer of environmental research and technologies into the marketplace. This catalog shares with you some of the innovative ideas that help clean your air, water and land, and contribute to a healthy environment.

The Federal FTTA Program was established to promote collaboration between private and federal research. EPA offers exceptional opportunities to develop and commercialize new technologies and move technologies newly developed in federal laboratories into our economy.

Through Cooperative Research and Development Agreements, or CRADAs,

collaborative relationships are established and all parties' intellectual property is protected. Licensing Agreements allow outside entities to license EPA-patented products and methods and quickly introduce them to the marketplace.

Partners in the FTTA Program will have the benefit of collaborating with world class EPA scientists involved in leading-edge research. Through FTTA partnerships, our collaborators will have access to EPA's scientific knowledge base and the opportunity to work through our laboratories to develop and commercialize shared innovations.

For further information on the broad spectrum of technologies available for licensing and further development, please visit <http://www.epa.gov/osp/ftta.htm>.



*"The innovative design allows an average fuel economy improvement of 30 to 40 percent over gasoline engines and produces the lowest known engine-out NOx ever achieved by any diesel engine."*

**Patent Title:** Low Emission Diesel Combustion System With Low Charge-Air Oxygen Concentration Levels and High Fuel Injection Pressures

**Patent:** 6,857,263

**Inventors:** Charles L. Gray, Jr., David Haugen, Karl Hellman

**Contact:**

David Read  
 U.S. EPA  
 National Vehicle and Fuel Emissions Laboratory  
 Ann Arbor, MI 48105  
 Telephone: 734-214-4367  
 read.david@epa.gov  
 www.epa.gov/otaq/technology

## Meeting the Challenge

### Clean, Economical Gasoline Alternatives

Diesel has long been a more fuel-efficient alternative to the standard gasoline-powered automobile. Diesel has a typical fuel efficiency improvement of 25 to 40 percent over gasoline. Although diesel engines produce less carbon dioxide, they also have been known for emitting particulate matter and nitrous oxides (NOx) into the environment. That may be changing with EPA's clean diesel technology, including a new combustion technology developed by Charles Gray, David Haugen, and others in EPA's National Vehicle and Fuel Emissions Laboratory in Ann Arbor, Michigan.

Clean diesel combustion (CDC) was developed and patented by EPA to maintain diesel's efficiency while making the engine run ultra-clean in a cost-effective manner. CDC produces the lowest known engine-out NOx ever achieved by any diesel engine. NOx can react in the atmosphere to form ground-level ozone, which can be detrimental to human health. This engine produces less NOx through a series of design changes to the diesel engine to develop in-cylinder NOx control, thereby preventing NOx emissions while maintaining or improving engine efficiency. The innovative engine design also maintains the economic fuel improvement over gasoline engines.

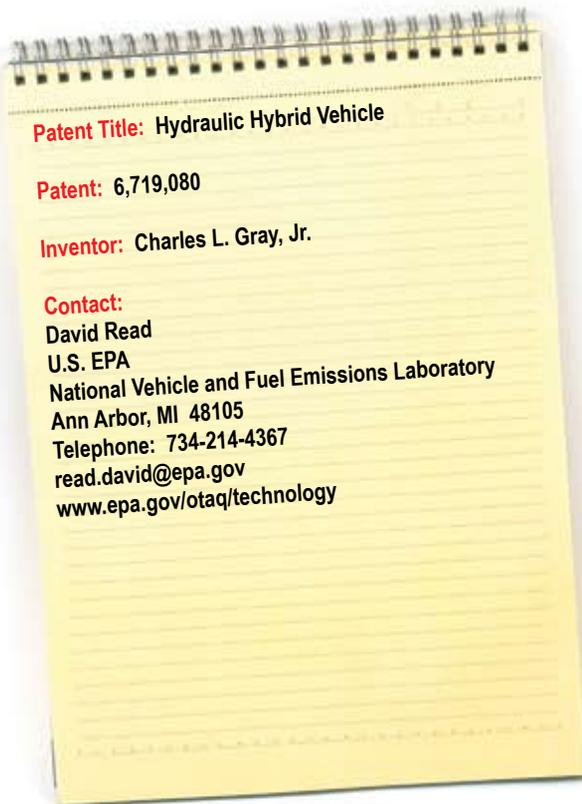


Because of CDC's potential to transform the diesel auto market, Ford Motor Company and International Truck and Engine Corporation have joined EPA in cooperative research and development agreements to demonstrate the technology. International Truck and Engine Corporation has made significant investments in advancing the CDC technology for consideration in its product line, and Ford has collaborated with EPA in installing a CDC engine in a Ford Galaxy minivan. Said Dr. Gerhard Schmidt, Vice President of Research and Advanced Engineering at Ford, "We are pleased to partner with EPA in this effort, recognizing that our research results can help meet key challenges facing the automotive industry. Ford's collaboration with EPA accelerates the development of technologies that will potentially enable the application of clean diesel engines across many vehicle platforms."

CDC is one of several emerging clean diesel technologies that promise to meet EPA's tailpipe emission standards and improve fuel economy in cars, SUVs, and trucks. Less than one percent of passenger vehicles in the United States currently are powered by diesel engines. In the future, however, clean diesel technologies such as CDC may allow more consumers to benefit from diesel's performance, durability and fuel efficiency.



*“The combination of the hydraulic hybrid technology and the CDC engine or high-efficiency alcohol engine will result in the world’s cleanest, most fuel-efficient, and most cost-effective urban delivery vehicle.”*



**Patent Title:** Hydraulic Hybrid Vehicle

**Patent:** 6,719,080

**Inventor:** Charles L. Gray, Jr.

**Contact:**

David Read

U.S. EPA

National Vehicle and Fuel Emissions Laboratory

Ann Arbor, MI 48105

Telephone: 734-214-4367

read.david@epa.gov

www.epa.gov/otaq/technology

## Moving Forward

### Hydraulic Hybrids in the Community

Hybrid vehicle technologies have become increasingly popular as gasoline prices have escalated in recent years. EPA scientists have developed an inventive and highly efficient full-series hydraulic hybrid vehicle powertrain. Charles Gray and other scientists at the National Vehicle and Fuel Emissions Laboratory have begun collaborating with external cooperators to install the hydraulic hybrid technology in SUVs and utility service vehicles.

The technology features a fully hydraulic hybrid powertrain and a unique and innovative hydraulic hybrid propulsion system integrated with the drive axle. The conventional transmission and transfer case have been removed and replaced with a hydraulic drivetrain. Hydraulic motors and hydraulic tanks are used to store energy, in contrast to the electric motors and batteries used in hybrid electric vehicles. Like other hybrid systems, energy saved when applying the brakes is reused to help accelerate the vehicle.

Through a cooperative research and development agreement, EPA is collaborating with the United Parcel Service (UPS), Eaton Corporation, International Truck and Engine Corporation, and the U.S. Army National Automotive Center to build and field test the world’s first full hydraulic hybrid urban delivery vehicle. The vehicle, a UPS delivery truck, exhibits significantly improved fuel economy and reduced harmful emissions.



The second phase of this project involves installing a clean diesel combustion (CDC) engine or high-efficiency alcohol engine into the hydraulic hybrid powertrain vehicle.

The combination of the hydraulic hybrid technology and the CDC engine or high-efficiency alcohol engine will result in the world’s cleanest, most fuel-efficient, and most cost-effective urban delivery vehicle. With the CDC engine, the vehicle will achieve a 90 percent reduction in nitrous oxides (NOx) emissions, thereby meeting the 2010 diesel emissions standards without the added cost of NOx aftertreatment, and will demonstrate 60 to 70 percent improved fuel economy, providing a fast payback for the cost of the technology. A typical urban delivery vehicle using this technology in stop-and-go traffic could save well over \$2,500 in fuel each year while significantly reducing pollution.



## Tracking Pollution to the Source

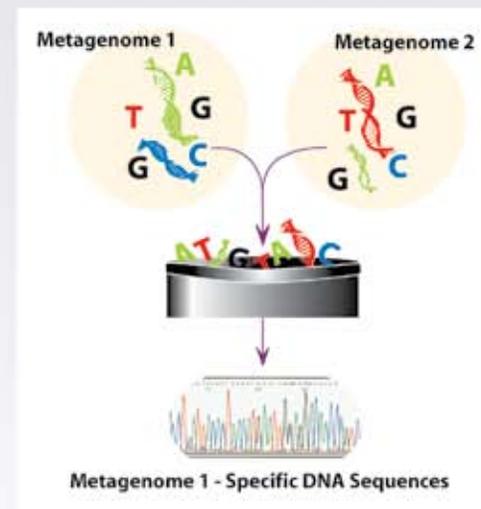
### *Advanced Microbial Source Tracking Assays and Genome Fragment Enrichment*

An innovative EPA patent pending technology provides an advanced tool for protecting recreational waters and drinking water sources. Newly developed microbial source tracking (MST) assays offer an improved method for distinguishing chicken, cattle and human sources of fecal contamination—a critical component for assessing health risks and determining necessary remedial actions.

Fecal bacterial contamination poses high risk to human health as well as the economy (e.g., when beaches or shellfish harvesting areas are affected). With proper identification of the source of fecal pollution, appropriate corrective measures can be implemented, and the cost of cleanup can be minimized. MST is used in water quality monitoring related to drinking water, post-hurricane cleanup, groundwater remediation and protection, runoff from concentrated animal feeding operations, and wastewater treatment plant effluents.

EPA researchers developed the advanced MST assays by creating a novel DNA sorting technique known as Genome Fragment Enrichment (GFE). The GFE technique identifies unique and divergent sequences between two DNA preparations. This approach has been used to characterize differences between closely related genomes and to compare total microbial DNA obtained from animal fecal specimens.

GFE has wider potential application in the field of comparative metagenomics. Metagenomics is an emerging field that provides genomic analysis of uncultured organisms and contributes to a wide range of end markets, including: aquaculture, meat production, crop protection, plant productivity, microbial hydrogen generation, pollution monitoring, antibiotics, vaccines, enzymes, fermentation processes, biotechnologies, bioprocessing and acid mine drainage.



*“Bacterial contamination in natural waters can be traced to specific animal sources, including humans, cows, chickens, seagulls and geese.”*

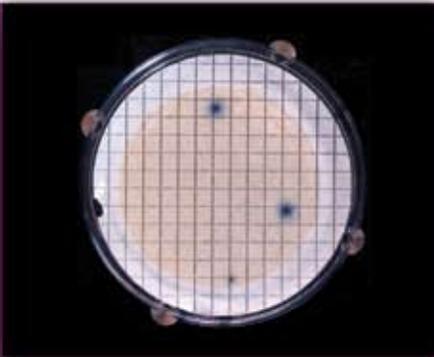
**Patent Title:** Development of Cow-Specific Primer Sets and Identification of Cow-Specific DNA Sequences Using Genome Fragment Enrichment

**Patent Pending:** 11/316,888

**Inventors:** Orin C. Shanks, Jorge Santo Domingo

**Contact:**

Orin C. Shanks  
 U.S. EPA  
 National Risk Management Research Laboratory  
 26 W. Martin Luther King Drive  
 Mail Code 387  
 Cincinnati, OH 45268  
 Telephone: 513-569-7314  
 E-mail: shanks.orin@epa.gov



*“This invention is a proven test for quick and accurate detection of bacterial contamination, with results available in 16 to 24 hours or less.”*

**Patent Title:** Membrane Filter Agar Medium Containing Two Enzyme Substrates Used for the Simultaneous Detection of Total Coliforms and *E. coli*

**Patents:** 6,063,590 / 6,306,621 / 6,670,145

**Inventors:** Kristen P. Brenner, Clifford C. Rankin, Yvette R. Roybal-McKenna, Alfred P. Dufour

**Contact:**

Kristen P. Brenner  
U.S. EPA  
26 W. Martin Luther King Drive  
Mail Code 314  
Cincinnati, OH 45268  
Telephone: 513-569-7317  
E-mail: [brenner.kristen@epa.gov](mailto:brenner.kristen@epa.gov)

## Protecting Our Water

### *A Fast, Accurate Technique for Detecting Pathogens*

Bacterial contamination of water supplies can pose a serious risk to human health. To protect the public and ensure safe water, EPA researchers have worked with private industry to develop a quick and accurate method of detecting *Escherichia coli* (*E. coli*) and total coliforms (TC).

TC include species that may inhabit the intestines of warm-blooded animals or occur naturally in soil, vegetation and water. They usually are found in fecally-polluted water and often are associated with disease outbreaks. Although they usually are not pathogenic themselves, their presence in drinking water indicates the possible presence of pathogens. *E. coli*, one species of the coliform group, is found in feces and, therefore, is an indicator of fecal contamination and the possible presence of enteric pathogens. In addition, some strains of *E. coli* are pathogenic.

Method 1604 is a sensitive and differential membrane filter method that uses membrane filter agar medium (MI Agar) or MI broth to identify TC and *E. coli*. Two enzyme substrates are included in the medium to detect enzymes that are produced by the bacteria. This method is a proven test for quick and accurate detection, with results available in 16 to 24 hours or less. It has been approved for use in monitoring drinking water, source water and ambient water (including fresh recreational water). It also has been proposed for use with groundwater and may be useful for analyzing other types of samples, such as treatment plant effluents, foods, pharmaceuticals, and human or veterinary clinical specimens.





*"The pervaporation system provides a sustainable method of removing VOCs from groundwater, soil-washing and soil-flushing solutions, and industrial waste streams."*

**Patent Title:** Recovery of Volatile Organic Compounds From Emulsion of Volatile Organic Compounds in Water by Pervaporation

**Patent:** 6,039,878

**Inventors:** Subhas K. Sikdar, Leland Vane

**Contact:**

Subhas K. Sikdar  
U.S. EPA  
26 W. Martin Luther King Drive  
Mail Code 235  
Cincinnati, OH 45268  
Telephone: 513-569-7528

## Reducing Waste

### *Clean and Sustainable Recovery of Volatile Organic Compounds*

Thousands of sites across the country are contaminated with volatile organic compounds (VOCs). A new EPA invention offers a clean and sustainable alternative to current remediation methods.

VOCs are used as solvents or as starting materials in a variety of industries, including plastics, paints, adhesives, parts degreasing and drycleaning. When released to the environment, VOCs can be harmful to human health and nature. An emerging cleanup approach relies on extracting VOCs into a water-based cleaning solution containing a detergent (surfactant). The resulting water-VOC-surfactant mixture is difficult to separate, and traditional technologies, such as air stripping and steam stripping, are hampered by foaming and precipitant formation problems.

EPA's new technology removes VOCs from the soil-cleaning solution using a membrane process called pervaporation. A nonporous membrane removes the VOCs selectively from the contaminated solutions, leaving behind the nonvolatile surfactant and other additives in the water stream. The VOCs are recovered in concentrated form, without air emissions, and then can be destroyed or reused.

The pervaporation system provides a sustainable method of removing VOCs from groundwater, soil-washing and soil-flushing solutions, and industrial waste streams. This invention could capture a share of the U.S. wastewater equipment market (estimated to be \$774 million in 2004 and anticipated to reach \$1.3 billion by 2011) as well as the U.S. soil and groundwater remediation technology market (estimated to be \$8 billion in 2004 and expected to reach \$13 billion by 2010).





*"This invention meets the economic need and the environmental demand for easy, efficient recovery and reuse of alcohols."*

**Patent Title:** Hydrophilic Mixed Matrix Materials Having Reversible Water Absorbing Properties

**Patent:** 6,881,364

**Inventors:** Leland Vane, Ravi Ponangi

**Contact:**

Leland Vane  
U.S. EPA  
26 W. Martin Luther King Drive  
Mail Code 443  
Cincinnati, OH 45268  
Telephone: 513-569-7799  
E-mail: vane.leland@epa.gov

## Recovery and Reuse

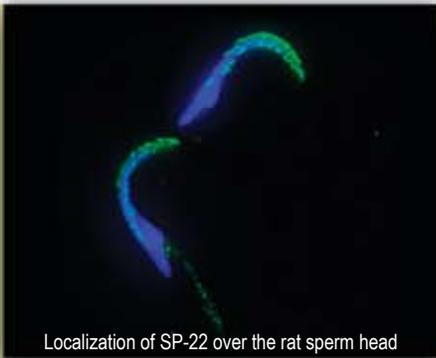
### Using Pervaporation To Recover and Reuse Alcohols

Pervaporation is an effective and sustainable method for remediating contaminated groundwater and industrial liquid waste streams. New advancements in this technology are expanding the range of its applications. One such advancement is the development of new, high performance hydrophilic membranes with reversible water-absorbing properties. This technology allows water to be transferred to or from an industrial process stream.

Many situations require this type of transfer; examples include the removal of water produced in a chemical reaction to drive the reaction to completion; the humidification of a gas stream to avoid desiccating materials, which requires the presence of moisture; and the dehydration of organic solvent streams to meet product specifications.

Alcohols are used increasingly as solvents and cleaning agents in various industries. Purification of alcohol streams that have been contaminated by water is difficult at certain concentrations. Such mixtures cannot be separated by normal distillation and require more complex processes. EPA's new hydrophilic membranes enable pervaporation operations to separate alcohol from water and allow the alcohol to be reused. This invention meets the economic need and the environmental demand for easy, efficient recovery and reuse of alcohols.





Localization of SP-22 over the rat sperm head

*"The applications are wide ranging and include new methods of contraception, screening for exposure to toxic pollutants, improved selection processes for animal breeding, and male fertility treatments."*

**Patent Title:** Method for Evaluating and Affecting Male Fertility

**Patent:** 6,197,940

**Inventor:** Gary Klinefelter

**Contact:**

Gary Klinefelter  
 U.S. EPA  
 Mail Code 72  
 Research Triangle Park, NC 27711  
 Telephone: 919-541-5779  
 E-mail: klinefelter.gary@epa.gov

## Advancing the Science of Reproductive Fertility *A Discovery With Wide-Ranging Applications*

A recent discovery in the science of reproductive fertility promises significant advances in this field. EPA scientists have identified a sperm protein, SP-22, that can be used to evaluate, inhibit or enhance male fertility. The applications for this are wide ranging and include new methods of contraception, screening for exposure to toxic pollutants, improved selection processes for animal breeding, and male fertility treatments.

The invention has been tested successfully in rats, rabbits, stallions, bulls and humans and has demonstrated a proof of concept. Specifically, this invention has the potential to:

- Provide a means for predicting male fertility in animals and humans.
- Screen animals and humans for exposure to known or suspected endocrine disruptors for fertility.
- Select sires that are good candidates for providing sperm for artificial insemination.
- Screen human semen for fertility to improve the success of assisted reproductive techniques.
- Improve fertility in males who fail to express a sufficient amount of SP-22, formerly known as SP-16, in sperm.
- Provide a reversible male contraceptive.

Currently, infertility affects approximately 6 million couples in the United States, and infertility diagnostics represents a multibillion dollar industry. There also is a need for an effective, reversible male contraceptive. This invention offers a much needed contribution in these areas as well as in the field of animal husbandry.





*“EPA researchers have developed an improved, cost-effective instrument for measuring the thickness of soft biological tissues.”*

**Title:** Electronic Caliper for Mouse Ear and Rat Foot Pad Edema Measurement

**Patent:** 6,829,839

**Inventor:** Paul M. Killough

**Contact:**

Paul M. Killough  
U.S. EPA

109 T. W. Alexander Drive  
Mail Code B-105-02  
Research Triangle Park, NC 27711  
Telephone: 919-541-2610  
E-mail: killough.paul@epa.gov

## Improving Precision

### *A New Instrument for Measuring Soft Tissues*

Many commercial and industrial applications, particularly biological research efforts involving animals, require measurements of soft, pliant objects. Numerous instruments for making these measurements have been developed, many of which are quite expensive. EPA researchers have developed an improved, cost-effective instrument for measuring the thickness of soft biological tissues.

Accurate and precise measurements are critical to obtaining sound scientific data. Commercially available calipers, however, apply too much force to the tissue, thus producing unreliable results. The improved design uses a very low-friction movable arm and a noncontact inductive sensor. Contact force applied by calipers of this design is adjustable from less than 1 to more than 5 grams. These calipers have been shown to apply exactly the same amount of force at each measured distance; in other words, they conform to Hooke's law where force applied is proportional to distance measured.

Two versions of this caliper have been constructed. The first unit has a measuring range of 0 to 2 mm for measuring the thickness of the ear of an anesthetized mouse. In a standard test for chemically induced hypersensitivity, the test article is injected into the pinna of one ear and a control substance into the other. The caliper is used to detect and quantify differences in swelling attributable to the sensitizing potential of the test article. The second unit has a range of 0 to 10 mm and is used to measure the thickness of the foot pad of an anesthetized rat. This assay is used to evaluate effects of pollutants on the ability of the immune system to respond to antigen challenge.

This invention may find use in a small subcategory (approximately \$30 million) of the measuring instrument market, estimated to be \$1 billion.





*"The BCR's simple operation and low maintenance requirements may render it economically more feasible than other water treatment technologies."*

**Patent Title:** Biomass Concentrator Reactor

**Patent:** 6,821,425

**Inventors:** Albert D. Venosa, Makram T. Suidan

**Contact:**

Albert D. Venosa  
U.S EPA

26 Martin Luther King Drive  
Mail Code 489A

Cincinnati, OH 45268

Telephone: 513-569-7668

E-mail: venosa.albert@epa.gov

## Caring for the Nation's Water Supply *Safe, Energy-Efficient Water Treatment Technology*

The quality of the nation's water supply is of increasing importance as the population continues to grow and urban areas expand. Surface waters from streams, rivers and other water bodies and wastewater from homes, industries and businesses require treatment to reduce pollutants and ensure public safety. Biological treatment is the most widely used technology to treat wastewater, and a new EPA patent promises a safer, more energy-efficient component to this process. This process also is gaining popularity for the treatment of drinking water.

The new, gravity-flow biomass concentrator reactor (BCR) effectively retains and concentrates suspended solids from treated water. The design encompasses an aeration chamber housing a high surface area porous polyethylene membrane system that retains all of the biomass within the aeration chamber. Its simple operation and low maintenance requirements may render it more economical than other water treatment technologies.

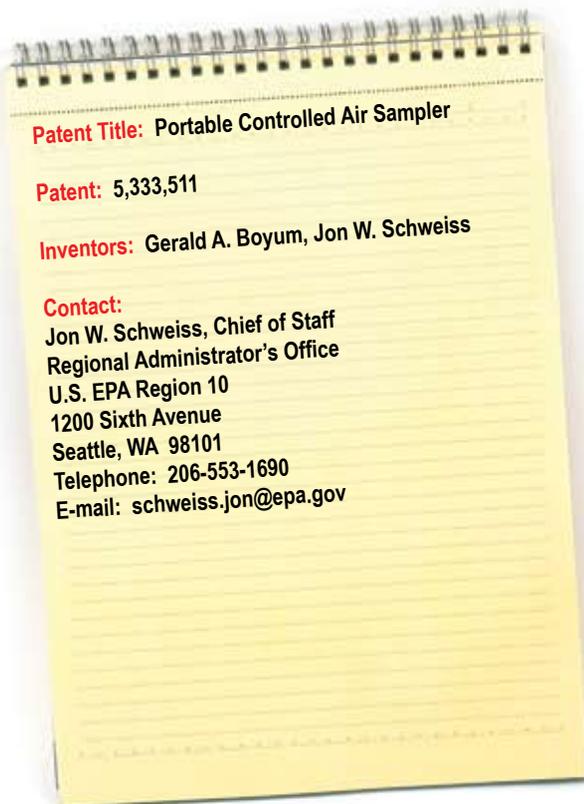
The BCR has been demonstrated to be effective in any environment where high biomass retention is desired or required for highly efficient biodegradation to occur. For example, it has proved effective in the biological treatment of methyl tertiary butyl ether (MTBE)-contaminated groundwater. MTBE is a gasoline additive that contaminates groundwater when underground storage tanks leak gasoline into the aquifer.

This technology could be used as a package plant replacement or for small municipal activated sludge systems (no clarifier needed) as well as for treating surface water for drinking purposes. It produces a clear and organic-free effluent, and it reduces natural organic matter sufficiently that trihalomethane precursors would be minimized. It can be used for industrial wastewater treatment and possibly for the anaerobic treatment of waters contaminated with perchlorates.

This invention holds potential for improving municipal wastewater treatment facilities. Biological wastewater treatment is a \$15 billion industry and is critical for the health and well being of the nation.



*“The inexpensive, low-volume sampler is used in a broad variety of sampling environments by virtue of its compact, lightweight, highly portable, weatherproof and rugged design.”*



**Patent Title:** Portable Controlled Air Sampler

**Patent:** 5,333,511

**Inventors:** Gerald A. Boyum, Jon W. Schweiss

**Contact:**

Jon W. Schweiss, Chief of Staff  
Regional Administrator's Office  
U.S. EPA Region 10  
1200 Sixth Avenue  
Seattle, WA 98101  
Telephone: 206-553-1690  
E-mail: [schweiss.jon@epa.gov](mailto:schweiss.jon@epa.gov)

## Serving Needs Worldwide

### Advanced Technology for Monitoring Air Quality

The saturation sampler is an outstanding example of a collaborative development that is reaching the international marketplace and serving needs worldwide. Numerous efforts, ranging from monitoring indoor air quality to responding to catastrophic events, have incorporated this advanced air sampling technology.

Jointly developed by EPA and the Lane Regional Air Pollution Authority, the saturation sampler reflects a unique integration, expansion and implementation of existing technologies. A U.S. patent was awarded for its ability to collect both filter and whole air samples in simultaneous, overlapping and/or individual monitoring regimes. The inexpensive, low-volume sampler is used in a broad variety of sampling environments by virtue of its compact, lightweight, highly portable, weatherproof and rugged design. It is used by private and public sector entities in a wide array of applications worldwide, including:

- Evaluating the representativeness and informing the design of fixed monitoring air monitoring networks and programs
- Informing the development and verifying the performance of air quality dispersion models
- Developing air emissions permits and monitoring compliance
- Conducting indoor air quality studies
- Conducting occupational air quality studies
- Conducting exposure/epidemiological studies
- Conducting air toxics studies
- Performing surveillance on airborne hazards to military personnel (e.g., at deployments in Afghanistan and Iraq)
- Responding to emergencies (e.g., measuring impacts in the aftermath of the World Trade Center attack, Gulf War/Kuwait oil well fires and volcanic eruptions).



More than 3,200 samplers have been sold domestically and internationally, with total revenues exceeding \$6 million. Approximately one-half of the 200-400 samplers sold annually now are purchased by international clients.



*“Pathogens can be identified quickly and accurately, allowing illnesses to be diagnosed and treated more effectively.”*

**Patent Title:** Method of Identifying and Quantifying Specific Fungi and Bacteria

**Patent:** 6,387,652

**Inventors:** Richard Haugland, Stephen Vesper

**Contact:**

Stephen Vesper  
U.S. EPA  
26 W. Martin Luther King Drive  
Mail Code 314  
Cincinnati, OH 45268  
Telephone: 513-569-7367  
E-mail: vesper.stephen@epa.gov

## Protecting Our Homes

### *A DNA-Based Innovation To Identify Molds and Bacteria*

Numerous health problems in the United States are associated with mold (i.e., fungi) in homes, schools and businesses. With a new technology developed by EPA researchers, these problems can be identified quickly and accurately, allowing illnesses to be diagnosed and treated more effectively. Perhaps more important, use of this technology may prevent disease occurrence.

EPA’s new DNA-based process can identify and quantify more than 130 species of toxic molds and potentially pathogenic fungi in the environment. Fungi and bacteria cause or contribute to many health problems, including infections, gastroenteritis, ulcers, asthma, allergies and sinusitis. This invention may have applications in research related to therapeutics and diagnostics for these illnesses. Additionally, this technology can be used to:

- Determine whether an environment is abnormally mold contaminated.
- Test homes for potentially pathogenic molds.
- Test water for pathogenic molds.
- Monitor hospitals to prevent nosocomial mold infections.
- Rapidly diagnose mold infections so that treatment can begin earlier.
- Monitor food and drugs for mold contamination.
- Measure the risk for mold associated with allergic and asthmatic disease.
- Diagnose chronic rhinosinusitis.
- Monitor crops for mold pathogens in an integrated pest management program, thus reducing the use of pesticides.



This method provides real-time results that are more accurate and less time-consuming than current technologies. EPA-licensed commercial laboratories in the United States and the European Union already use this method to provide service for their clients.



*“By reducing the accumulation of sewer solids in pipes, the new system can optimize performance, maintain structural integrity and minimize pollution in receiving waters.”*

**Patent Title:** System and Method for Vacuum Flushing Sewer Solids

**Patent:** 6,655,402

**Inventor:** Chi-Yuan Fan

**Contact:**

Richard Field  
U.S. EPA  
Urban Watershed Management Branch  
2890 Woodbridge Avenue  
Mail Code 104  
Edison, NJ 08837-3679  
Telephone: 732-321-6674  
E-mail: field.richard@epa.gov

## Protecting the Community

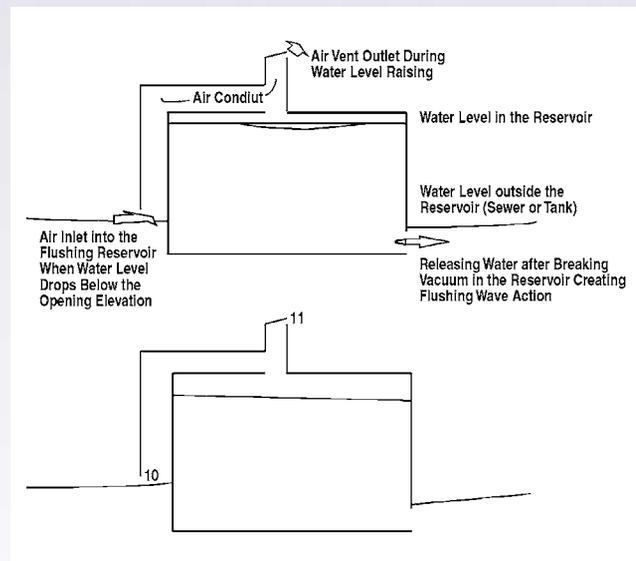
### Technologies To Improve Urban Drainage Systems

EPA's new patented vacuum flushing method promises a significant improvement to current urban drainage systems. By reducing the accumulation of sewer solids in pipes, the new system can optimize performance, maintain structural integrity and minimize pollution in receiving waters.

Combined sewer overflows, stormwater runoff and sanitary sewer overflows are major contributors to the degradation of many urban lakes, streams and rivers. During heavy rainstorms, wet weather flows often exceed the capacity of current sewer systems and wastewater treatment plants and, consequently, discharge the excess into receiving waters. Moreover, during periods of low rainfall, water velocity in drainage systems is reduced, allowing sewer solids to settle in pipes. Subsequent rainstorms may resuspend these accumulated solids, creating extremely high concentrations of suspended solids, which because of the limited capacity of many systems, can overflow into receiving waters and produce detrimental shock loadings.

Accumulated solids also restrict and/or block drainage flow, which can cause an upstream surge or local flooding. Accumulated sewer solids also create septic conditions that pose odor, health hazards and corrosion problems.

The new system is a cost-effective means of removing sewer solids from urban drainage systems between storms and, therefore, reducing the amount of pollutants that reach receiving waters. It operates under atmospheric pressure and hydrostatic buildup and does not require complex control instrumentation or an extramural source of water for flushing. This technology meets an ongoing need for improved protection of the health and safety of water systems in urban environments.





*“The avoidance of costs associated with sludge removal combined with revenue from the sale of recovered metals may provide a return on investment that surpasses comparable processes.”*

**Patent Title:** Recovery of Metals From Metal-Bearing Acidic Waste Streams

**Patent Pending:** 11/224,039

**Inventors:** John O. Burckle, Fred K. Kawahara, Rakesh Govind, Henry H. Tabak, and Richard A. Scharp.

**Contact:**

Richard Scharp  
U.S. EPA  
26 W. Martin Luther King Drive  
Mail Code 445  
Cincinnati, OH 45268  
Telephone: 513-569-7496  
E-mail: burckle.john@epa.gov

## Products from Waste

### *A Cost-Effective Alternative for Recovering Metals and Treating Industrial Wastewater*

EPA scientists have developed an improved method for treating industrial wastewater to recover metals in a commercially valuable form. The process involves the sequential removal of metal species from an acidic, sulfate-containing wastewater stream by pH control and sulfide or hydroxide precipitation. The sulfide used for metal precipitation is produced by hydrogen-consuming, sulfate-reducing bacteria in a membrane bioreactor. This method produces marketable, high-purity metal precipitates as well as an effluent stream that meets EPA water quality “Gold Book Standards.” In a two-step process, the metals are precipitated in individual stages to achieve separation, and the metal-free wastewater is treated to remove the sulfate as hydrogen sulfide. The metals are removed as high-purity (90%+ based on metals content) metal sulfide or hydroxide precipitates that are suitable for existing markets or conversion to commodities. Recovered compounds include: copper sulfide, zinc sulfide, manganese sulfide and aluminum hydroxide. Excess hydrogen sulfide can be converted to sodium hydrosulfide solution, a commodity chemical used in paper pulping processes. Alternatively, an advanced bioconversion technology can be used to combine the bioreactor and precipitation steps into a single process unit for each of the metals requiring sulfide precipitation.

This technology offers a cost-effective alternative for recovering metals and treating industrial wastewater. The avoidance of costs associated with sludge removal combined with revenues from recovered metals may provide a return on investment that surpasses comparable processes. A pay-back time of 6 to 18 months has been projected based on commodity value ranges. The significance of this technology includes the following:

- Waste sludge (i.e., RCRA products), which is associated with current lime precipitation processes, is not produced.
- Accessory metals, such as arsenic, cadmium, cobalt, nickel and ferric iron, can be removed. The presence of accessory metal in the resulting product compares satisfactorily with that found in natural ores.
- The high-purity precipitates are in acceptable forms for existing markets.
- The water produced is suitable for discharge.

Initially developed to treat acid mine drainage wastewater, this process has potential applicability for many metal-bearing wastewaters. Future research partners may include hard-rock and coal mine operators, industrial wastewater generators, wastewater treatment process and/or equipment vendors, and remediation contractors.



## Restoring the Soil

### *Earth-Friendly Alternatives to Chemical Remediation*

Subsurface pollution is an environmental issue of great concern in the United States and around the world. Bioremediation has proven to be an effective and environmentally preferable treatment for biodegradable pollutants, such as methyl tertiary butyl ether, toluene, ethylbenzene, xylenes and others. Performance of bioremediation, however, has been limited because it can be difficult to access the contamination in subsurface soil and because, in most cases, bioremediation requires oxygen, which is highly insoluble in water. Researchers at EPA have developed an advanced bioremediation process for subsurface treatment of soil pollution that solves these problems.

Bioremediation relies on microorganisms to break down pollutants into nontoxic matter. To access the subsurface, hydraulic fracturing was adapted by EPA from the oil drilling industry. A hole is drilled into the contaminated area, and high pressure water cracks the subsurface layers. Microorganisms then are introduced into the fractures, where they begin to degrade the pollutants. Because microorganisms require oxygen, it is pumped either as air or oxygenated water into the cracks. In both cases, the oxygen is lost quickly from the bioremediation process. EPA developed encapsulated sodium percarbonate, called Solid Oxygen Source (SOS), to provide a slow, constant and controlled release of oxygen for use by the microorganisms to degrade the pollutants. The SOS can be delivered in the hydraulic fracturing water directly to the site of the contamination in the soil.

Hydraulic fracturing combined with the SOS offers numerous advantages over standard bioremediation methods. Operational costs are minimized because equipment maintenance is not required (i.e., surface pumps or meters, which tend to freeze and fail, are not needed); the process does not spread pollutants; and the slow release of oxygen provides a long-term treatment.

Bioremediation is part of the multibillion dollar U.S. remediation industry and has application worldwide. With growing concern about hazardous chemical remediation methods, bioremediation likely will increase in importance as an environmentally preferable remediation alternative.

*“With growing concern about hazardous chemical remediation methods, bioremediation likely will increase in importance as an environmentally preferable remediation alternative.”*

**Patent Title:** Process for Biodegradation of Contaminants in Subsurface Soil by Introduction of Hydraulic Fracturing of a Stable Solid Oxygen Source and Other Amendments

**Patent Pending:** 09/866,793

**Inventors:** Wendy Davis-Hoover, Stephen Vesper

**Contact:**

Wendy Davis-Hoover

U.S. EPA

National Risk Management Research Laboratory

National Homeland Security Research Center

5995 Center Hill Avenue

Cincinnati, OH 45224

Phone: 513-569-7206

E-mail: [davis-hoover.wendy@epa.gov](mailto:davis-hoover.wendy@epa.gov)



*"This technology can enhance or control tissue growth and repair by targeting specific ions."*

## Enhancing Medical Research

### *Advancements in Electromagnetic Therapy*

Research often has unexpected and far-reaching benefits. This method to enhance tissue growth was an outcome from EPA's research into the health effects of chemicals introduced into drinking water by the disinfection process.

EPA research focused on the underlying molecular targets responsible for cancer induction in animal models. EPA scientists designed and conducted a series of tests of disinfection by-products and closely related chemicals that revealed different concentration response curves but otherwise exhibited no additional characteristics upon which to develop a mode of action (MoA). The principal investigator decided to use magnetic fields and melatonin, which had been shown to enhance the tumor-suppressor function, as tools to reveal underlying characteristics that would aid in the development of an MoA. Results with both tools allowed for segregation of the chemicals into otherwise indistinguishable subgroups. The investigator, aware of activities in other research areas where these tools were beginning to be used, inadvertently discovered treatment conditions that allowed for more refined and precise methods and applications for healing bones and enhancing tissue growth in human and animal models.

This patented methodology describes how to preferentially stimulate certain ions within tissues or cells. Clinical and animal research has shown that ionic stimulation by magnetic fields has increased the rate of cellular activity or bone growth in broken or damaged bones. In some cases, ionic stimulation has improved or increased the total amount of bone density. The methodology also has application in nervous system processes including nerve growth.

**Patent Title:** Method and Apparatus for Altering Ionic Interactions With Magnetic Fields

**Patent:** 5,919,679

**Inventors:** Carl F. Blackman, Janie Page

**Contact:**

Carl F. Blackman  
U.S. EPA  
Mail Code B-143-06  
109 T.W. Alexander Drive  
Research Triangle Park, NC 27711  
Telephone: 919-541-2543  
E-mail: blackman.carl@epa.gov



